BULLETIN 676

10-YEAR PAINT TESTS ON WEATHERED GALVANIZED ROOFING

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CONTENTS

COVER PHOTO — *the 150-foot corn crib on which the paint study was conducted (south side after application of first coat of paint).*

This bulletin was prepared by A. J. Muehling and J. O. Curtis, Assistant Professors of Agricultural Engineering.

The research reported here was initiated by R. W. Whitaker, formerly Instructor of Agricultural Engineering, now Director of Agricultural Research, A. O. Smith Corporation, Milwaukee, under the direction of D. G. Carter, Professor of Agricultural Engineering.

For several years, inspections of the test panels were conducted in the Department by H. L. Wakeland, now Assistant Dean of the College of Engineering, University of Illinois.

Funds for this project were provided in part by the American Zinc Institute and the Aluminum Company of America.

Galvanized metal sheets are steel sheets that have been coated with zinc to prevent the steel from rusting. As this zinc coating deteriorates through weathering, the steel becomes exposed and begins to rust. Besides being unsightly, rusting reduces the life of the roofing.

Galvanized metal roofing and siding are used extensively on farm buildings. A 1941-1942 survey (8)* by the American Zinc Institute in 36 states east of the Rocky mountains showed that one-third of all farm buildings had galvanized steel roofs. More than one-fourth of these roofs were rusty. According to a 1944-1954 survey (7), the roofs of about one-half of all Illinois farm buildings were made of galvanized steel. About 50 percent of these roofs showed signs of rust.

The application of protective paints is one of the least expensive means of preventing rusting of galvanized metal sheets, provided that the paint is chosen carefully. Painting also makes the building more attractive and can reduce roof temperatures by reflection.

Paints vary in their ability to adhere to metals, to withstand exposure, and to prevent rusting. Manufacturers' tests indicate the relative ability of paints to protect metal from corrosion. However, the final evaluation of a particular paint can be obtained only by direct exposure to the elements. According to several authorities (5, 10) accelerated laboratory tests do not predict the service life of a paint, and the final trial should be under field conditions.

In 1932, the American Zinc Institute established tests of paints on galvanized metal roofs at Donnellson, Illinois. These tests are usually referred to as the Harwood Tests. In 1948, test data covering 16 years were turned over to the Department of Agricultural Engineering at the University of Illinois. The data were analyzed and the results published (3, 4).

After studying the results of the Harwood Tests and reviewing other technical literature on paint for metal roofs, the University of

* This number and similar numbers in parentheses refer to the literature citations on page 27.

Illinois Department of Agricultural Engineering initiated a new series of paint tests in June, 1949. This project was supported in part with funds supplied by the American Zinc Institute and the Aluminum Company of America.

The objective of these tests was to expand the knowledge gained from the Harwood Tests. Information was sought concerning (a) the durability of metallic zinc paints for priming and finish coats on rusty galvanized metal roofing; (b) the durability of aluminum paints as finish coats over various primers; and (c) the value of wire brushing the rusty surface before painting.

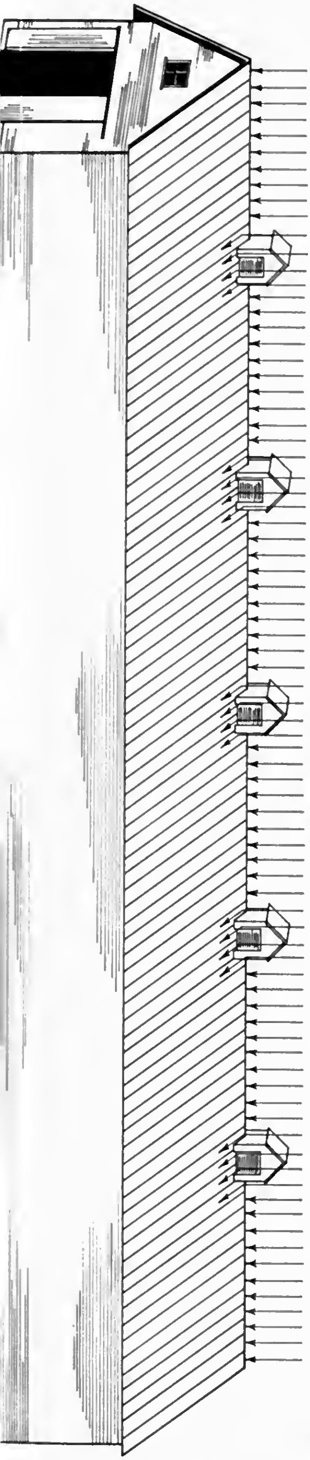
The roof of a 150-foot crib on one of the University-owned Allerton farms near Monticello, Illinois, was chosen for the tests (see cover photo). The rural location corresponded to the least severe ordinary exposure condition, according to the classification of atmospheric types used by the American Society for Testing Materials (11). The condition of the galvanized sheets on this roof did not vary as much as the condition of the sheets used in the Harwood Tests. Much of the metal was quite rusty. A trace of black asphalt paint remained on most sheets from a previous painting. These surface conditions were as severe as one would be likely to encounter in farm buildings.

DESCRIPTION OF TESTS

Application of Paints

Each panel was composed of corrugated metal sheets approximately 2 feet wide and extending up one side of the crib and down the other. This arrangement gave a north and south exposure for each panel. Before painting, all panels were renailed where needed, and the entire roof was brushed with a broom to remove all loose foreign material. A three-foot strip of roof was wire brushed across the northern exposure of panels 46 through 81 to evaluate the practice of wire brushing a rusty galvanized sheet before painting.

Twenty-three paints from 11 manufacturers were hand-sprayed on the test panels in 7 one-coat and 34 two-coat applications. Replications were made of all but two panels (panels 11 and 16). In addition to giving better test data, these replications provided some insurance against a complete loss of record in the event that some of the sheets were blown off the roof. Fig. 1 shows the numbered panels on the crib and lists the paint combinations that were tested. The compositions of the paints as reported by the manufacturers are listed in Table 1.



	FIRST COAT	SECOND COAT
1	GRAY MZP (SOYBEAN OIL)	GRAPHITE
2	GRAY MZP (SOYBEAN OIL)	RED MZP
3	ZINC CHROMATE PRIMER	RED MZP
4	ZINC CHROMATE-IRON OXIDE	RED MZP
5	RED LEAD (LINSEED OIL)	RED MZP
6	WHITE LEAD	RED MZP
7	RED MZP	RED MZP
8	RED MZP	NONE
9	IRON OXIDE (RED RUST-RESISTING PAINT)	IRON OXIDE (RED RUST-RESISTING PAINT)
10	GREEN MZP	NONE
11	GREEN MZP	GREEN AUTO ENAMEL
12	GREEN AUTO ENAMEL	GREEN MZP
13	GRAY MZP (LINSEED OIL)	ALUMINUM, FOR METAL & MASONRY (I)
14	RED LEAD (LINSEED OIL)	ALUMINUM, FOR METAL & MASONRY (I)
15	RED LEAD (SEMI-QUICK-DRYING VEHICLE)	ALUMINUM, FOR METAL & MASONRY (I)
16	ZINC CHROMATE-IRON OXIDE	ALUMINUM, FOR METAL & MASONRY (I)
17	ZINC CHROMATE PRIMER	ALUMINUM, FOR METAL & MASONRY (I)
18	ALUMINUM, GENERAL PURPOSE (I)	NONE
19	ALUMINUM, GENERAL PURPOSE (I)	ALUMINUM, GENERAL PURPOSE (I)
20	GRAY MZP (SOYBEAN OIL)	ALUMINUM, FOR METAL & MASONRY (I)
21	GRAY MZP (SOYBEAN OIL)	ALUMINUM, GENERAL PURPOSE (II)
22	GRAY MZP (SOYBEAN OIL)	ALUMINUM (RUST-RESISTING VEHICLE)
23	GRAY MZP (LINSEED OIL)	ALUMINUM (RUST-RESISTING VEHICLE)
24	GRAY MZP PRIMER	ALUMINUM (RUST-RESISTING VEHICLE)
25	RED LEAD OXIDE (LINSEED OIL)	ALUMINUM (RUST-RESISTING VEHICLE)
26	GRAY MZP PRIMER	ALUMINUM, GENERAL PURPOSE (II)
27	ALUMINUM (RUST-RESISTING VEHICLE)	NONE
28	ALUMINUM (RUST-RESISTING VEHICLE)	ALUMINUM (RUST-RESISTING VEHICLE)
29	RED LEAD OXIDE (LINSEED OIL)	ALUMINUM, FOR METAL & MASONRY (II)
30	GRAY MZP (SOYBEAN OIL)	ALUMINUM, FOR METAL & MASONRY (II)
31	GRAY MZP (SOYBEAN OIL)	ASPHALT ALUMINUM
32	ASPHALT ALUMINUM	ASPHALT ALUMINUM
33	ASPHALT ALUMINUM	NONE
34	ASBESTOS ASPHALT	ASPHALT ALUMINUM
35	ALUMINUM, FOR METAL & MASONRY (I)	NONE
36	ALUMINUM, FOR METAL & MASONRY (I)	ALUMINUM, FOR METAL & MASONRY (I)
37	ALUMINUM, SPECIAL	ALUMINUM, SPECIAL
38	GRAY MZP (SOYBEAN OIL)	ALUMINUM, GENERAL PURPOSE (I)
39	GRAY MZP (SOYBEAN OIL)	NONE
40	GRAY MZP (SOYBEAN OIL)	GRAY MZP (SOYBEAN OIL)
41	SPECIAL RED PRIMER (NORTH ONLY)	GRAY MZP (SOYBEAN OIL) (NORTH ONLY)
42	GRAY MZP (SOYBEAN OIL)	GRAPHITE
43	GRAY MZP (SOYBEAN OIL)	RED MZP
44	ZINC CHROMATE PRIMER	RED MZP
45	ZINC CHROMATE-IRON OXIDE	RED MZP
46	RED LEAD (LINSEED OIL)	RED MZP
47	WHITE LEAD	RED MZP
48	RED MZP	RED MZP
49	RED MZP	NONE
50	IRON OXIDE (RED RUST-RESISTING PAINT)	IRON OXIDE (RED RUST-RESISTING PAINT)
51	GREEN MZP	NONE
52	GREEN MZP	GREEN MZP
53	GREEN AUTO ENAMEL	GREEN MZP
54	GREEN MZP (LINSEED OIL)	ALUMINUM, FOR METAL & MASONRY (I)
55	RED LEAD (LINSEED OIL)	ALUMINUM, FOR METAL & MASONRY (I)
56	RED LEAD (SEMI-QUICK-DRYING VEHICLE)	ALUMINUM, FOR METAL & MASONRY (I)
57	SPECIAL RED PRIMER	ALUMINUM, FOR METAL & MASONRY (I)
58	ZINC CHROMATE PRIMER	ALUMINUM, FOR METAL & MASONRY (I)
59	ALUMINUM, GENERAL PURPOSE (I)	NONE
60	ALUMINUM, GENERAL PURPOSE (I)	ALUMINUM, GENERAL PURPOSE (I)
61	GRAY MZP (SOYBEAN OIL)	ALUMINUM, FOR METAL & MASONRY (I)
62	GRAY MZP (SOYBEAN OIL)	ALUMINUM, GENERAL PURPOSE (II)
63	GRAY MZP (SOYBEAN OIL)	ALUMINUM (RUST-RESISTING VEHICLE)
64	GRAY MZP (LINSEED OIL)	ALUMINUM (RUST-RESISTING VEHICLE)
65	GRAY MZP PRIMER	ALUMINUM (RUST-RESISTING VEHICLE)
66	RED LEAD OXIDE (LINSEED OIL)	ALUMINUM (RUST-RESISTING VEHICLE)
67	GRAY MZP PRIMER	ALUMINUM, GENERAL PURPOSE (II)
68	ALUMINUM (RUST-RESISTING VEHICLE)	NONE
69	ALUMINUM (RUST-RESISTING VEHICLE)	ALUMINUM (RUST-RESISTING VEHICLE)
70	RED LEAD OXIDE (LINSEED OIL)	ALUMINUM, FOR METAL & MASONRY (II)
71	GRAY MZP (SOYBEAN OIL)	ALUMINUM, FOR METAL & MASONRY (II)
72	GRAY MZP (SOYBEAN OIL)	ASPHALT ALUMINUM
73	ASPHALT ALUMINUM	ASPHALT ALUMINUM
74	ASPHALT ALUMINUM	NONE
75	ASBESTOS ASPHALT	ASPHALT ALUMINUM
76	ALUMINUM, FOR METAL & MASONRY (I)	NONE
77	ALUMINUM, FOR METAL & MASONRY (I)	ALUMINUM, FOR METAL & MASONRY (I)
78	ALUMINUM, SPECIAL	ALUMINUM, SPECIAL
79	GRAY MZP (SOYBEAN OIL)	ALUMINUM, GENERAL PURPOSE (I)
80	GRAY MZP (SOYBEAN OIL)	NONE
81	GRAY MZP (SOYBEAN OIL)	GRAY MZP (SOYBEAN OIL)

Paint treatment for each panel of the corn-crib roof used in the tests. (Fig. 1)

Table 1. — Composition of Paints by Percent of Weight

Paint No.	Description	Panels painted[a]		Composition of paints as reported by manufacturer					
		First coat	Second coat	Pigment	Percent of pigment	Percent of total	Vehicle	Percent of vehicle	Percent of total
1	Gray MZP (soybean oil)	1, 2, 20, 21, 22, 30, 31, 38, 39, 40, 42, 43, 61, 62, 63, 71, 72, 79, 80, 81	40, 41, 81	Zinc dust Zinc oxide Zinc stearate	79.6 19.8 .6	78.9	Soybean oil Linseed oil Mineral spirits	60.4 30.1 9.5	21.1
2	Graphite	none	1, 42	Graphite Inert	63.5 36.5	50.0	Pure linseed oil Drier Mineral spirits	60.0 10.0 30.0	50.0
3	Red MZP	7, 8, 48, 49	2, 3, 4, 5, 6, 7, 43, 44, 45, 46, 47, 48	Zinc dust Zinc oxide Magnesium silicate Red iron pigment (87% ferric oxide)	50.0 20.0 8.9 21.1	65.9	Vegetable oil (Linseed oil 60%, Soybean oil 40%) Thinner & drier	95.4 4.6	34.1
4	Zinc chromate primer	3, 17, 44, 58	none	Zinc chromate Red lead (95% grade) Zinc oxide Iron oxide (85%) Magnesium silicate	20.0 25.0 15.0 20.0 20.0	60.0	Vegetable oils Varnish (Vegetable oils, 42%; resin, 8%; mineral spirits, 50%) Japan drier Mineral spirits	24.0 50.0 15.0 11.0	40.0
5	Zinc chromate — iron oxide	4, 16, 45	none	Iron oxide Zinc chromate Magnesium silicate & calcium carbonate Zinc oxide	12.0 37.0 49.0 2.0	55.0	Synthetic resin solution Drier Solvent	64.0 5.0 31.0	45.0
6	Red lead (linseed oil)	5, 14, 46, 55	none	Red lead	100.0	93.0	Linseed oil	100.0	7.0
7	White lead	6, 47	none	Basic carbonate of white lead	100.0	71.5	Linseed oil Mineral spirits Drier	65.0 32.0 3.0	28.5
8	Iron oxide (red rust-resisting paint)	9, 50	9, 50	Chemically pure zinc chromate Magnesium silicate Iron oxide Aluminum Calcium carbonate Unknown	20.0 17.0 25.0 7.0 27.0 4.0	51.0	Raw linseed oil Alkyd resin Drier Penetrating thinner	42.0 20.0 5.0 33.0	49.0
9	Green MZP	10, 11, 51, 52	12, 52, 53	Metallic zinc Zinc oxide Magnesium silicate Chrome green	75.0 4.0 5.0 16.0	71.9	Vegetable oil Thinner & drier	91.9 8.1	28.1
10	Green auto enamel	12, 53	11	Iron blue Lead chromate Rutile titanium dioxide Carbon black	45.2 45.0 5.7 4.1	9.6	Drying oil alkyd 24% Lead naphthanate solution 6% Cobalt naphthanate solution 6% Manganese naphthanate solution Petroleum hydrocarbon solvent	39.9 1.2 .5 .3 58.1	90.4

Table 1. — Concluded

Paint No.	Description	Panels painted[a]: First coat	Panels painted[a]: Second coat	Composition of paints as reported by manufacturer: Pigment	Percent of pigment	Percent of total	Vehicle	Percent of vehicle	Percent of total
11	Gray MZP (linseed oil)	13, 23, 54, 64	none	Metallic zinc Zinc oxide	80.0 20.0	79.0	Linseed oil Thinner & drier	90.0 10.0	21.0
12	Aluminum, for metal & masonry (I)[b]	35, 36, 76, 77	13, 14, 15, 16, 17, 20, 36, 54, 55, 56, 57, 58, 61, 77	Aluminum paste	100.0	30.0	Pentaerythritol resin Linseed oil Tung oil Soybean oil Volatile	13.0 23.2 9.7 8.1 46.0	70.0
13	Red lead (semi-quick-drying vehicle, oil-type	15, 56	none	Red lead	100.0	77.0	Linseed oil Turpentine Driers	84.0 9.0 7.0	23.0
14	Aluminum, general purpose (I)[b]	18, 19, 59, 60	19, 38, 60, 79	Aluminum paste	100.0	17.0	Vegetable oils Resins Mineral spirits	24.0 22.0 54.0	83.0
15	Aluminum, general purpose (II)[b]	none	21, 26, 62, 67	Chrome aluminum	100.0	15.8	Long oil spar varnish	100.0	84.2
16	Gray MZP primer	24, 26, 65, 67	none	Zinc oxide Zinc dust	20.0 80.0	76.0	Raw linseed oil Solvents & drier	91.3 8.7	24.0
17	Aluminum, (rust-resisting vehicle)	27, 28, 68, 69	22, 23, 24, 25, 28, 63, 64, 65, 66, 69	Aluminum paste	100.0	18.0	Bodied linseed oil Synthetic resin Drier Volatile thinner	43.0 12.5 1.0 43.5	82.0
18	Red lead oxide (linseed oil)	25, 29, 66, 70	none	Red lead Red iron oxide Magnesium silicate China clay	27.0 28.5 26.5 18.0	55.0	Raw linseed oil Heat-treated vegetable oil Thinner & drier	36.0 25.0 39.0	45.0
19	Aluminum, for metal & masonry (II)[b]	none	29, 30, 70, 71	Aluminum pigment (325 mesh)	100.0	14.0	Processed vegetable oils & resins Thinners & driers	55.0 45.0	86.0
20	Asphalt aluminum	32, 33, 73, 74	31, 32, 34, 72, 73, 75	Aluminum paste	100.0	21.1	Roof-coating vehicle	100.0	78.9
21	Asbestos asphalt	34, 75	none	Asbestos fiber Graphite Carbon black	30.0 62.6 7.4	15.0	Mineral spirits Cutback asphalt	11.0 89.0	85.0
22	Aluminum, special	37, 78	37, 78	unknown					
23	Special red primer	41 (north only), 57	none	unknown					

[a] Panels were numbered consecutively from 1 to 81 (west to east).
[b] Paints 12 and 19 were aluminum, for metal and masonry; paints 14 and 15 were aluminum, general purpose. These paints were numbered I and II for identification purposes.

ASTM standards D 1014-51 (11) was followed as closely as possible when setting up the test procedure. Singleton (9) states that when making paint tests, the description of a painting system must include at least three items: (a) the condition of the steel surface when it is painted, (b) the paint composition, and (c) the thickness of paint or amount of paint used on a given area.

Excellent colored slides showing the original condition of the panels were taken before the tests began. These slides were studied and the amount of rust on each panel was recorded (see pages 16 to 18). The condition of the panels before painting can be seen in Fig. 2.

Paint was hand-sprayed on the panels in consecutive order, starting with the first panel on the west end of the building. All paint was applied according to the manufacturers' directions by the same person using the same equipment.

The paint coatings were applied with a small (0.203 gallon) DeVilbiss pressure cup unit. An aluminum shield was used to prevent the spray from blowing to adjacent panels (Fig. 3). The sprayer cup was cleaned after each application except when the same paint was applied to successive panels. Panels that were to have the same paint were grouped together to reduce the time and labor required for washing the cup and maneuvering the shield.

Table 2 shows the amount of paint applied to each panel, weight per gallon, and the amount of coverage in square feet per gallon of each paint used. The values from Table 2 were determined by the following procedure:

1. The cup was filled to the 0.203-gallon capacity and weighed before the test panel was painted.

2. After the panel was painted, the weight of the cup was recorded.

3. The weight of the cup was subtracted from the full weight to obtain the pounds of paint applied.

4. Weight per gallon was calculated from the full weight of the cup, the known empty weight of the cup unit (3.43 pounds), and the known capacity of the cup (0.203 gallon).

Full weight minus empty weight (3.43 pounds) equals actual weight of 0.203 gallon of paint.

Weight per gallon equals 1/0.203 times actual weight of 0.203 gallon of paint.

The weight per gallon for a given paint sometimes varied slightly because of variation in mixing and in the quantity of thinner used (if any). See footnote b under Table 2 for paints thinned.

North side of crib before painting. The one-third of the roof at the left (Panels 46 through 81) was 100 percent rusty. (Fig. 2)

5. The gallons used per panel were calculated by dividing the weight of paint used per panel by the weight per gallon.

6. The actual areas for each panel were measured.

The coverage in square feet per gallon was calculated by dividing the panel area by the gallons used on the panel.

When the same paint was applied to successive panels, they were painted as a single unit and separate panel calculations were not made.

An aluminum shield was used to prevent spray from blowing to adjacent panels. (Fig. 3)

Table 2. — Area of Panels, Quantities of Paint Used, and Paint Coverage

Panel No.	Panel area (square feet)	First coat				Second coat			
		Paint No.[a]	Amount of paint used (pounds)	Weight per gallon (pounds)	Coverage (square feet per gallon)	Paint No.[a]	Amount of paint used (pounds)	Weight per gallon (pounds)	Coverage (square feet per gallon)
1	80.4	1	3.48	22.0	510	2	3.06	11.6	305
2	69.8	1	3.02	22.0	510	3	2.89	17.7	425
3	74.0	4	2.60	14.4	410	3	3.07	17.7	425
4	74.0	5	2.08	11.4	405	3	3.07	17.7	425
5[b]	72.2	6	5.25	31.1	425	3	2.99	17.7	425
6	71.9	7	3.45	18.6	390	3	2.98	17.7	425
7	74.0	3	2.88	16.2	415	3	3.07	17.7	425
8	68.4	3	2.66	16.2	415		....	....	...
9	66.6	8	2.39	11.7	325	8	1.95	12.0	410
10	71.8	9	4.01	17.7	315		....	....	...
11	74.0	9	4.12	17.7	315	10	2.25	8.3	275
12	76.0	10	2.25	8.1	270	9	2.35	18.7	600
13	78.2	11	4.79	25.0	405	12	1.50	7.9	410
14[b]	76.0	6	7.30	28.2	290	12	1.45	7.9	410
15	76.0	13	4.93	24.2	370	12	1.45	7.9	410
16[b]	76.0	5	2.58	11.5	340	12	1.45	7.9	410
17	76.0	4	4.38	14.5	250	12	1.45	7.9	410
18	76.0	14	1.47	7.7	395		....	....	...
19	76.0	14	1.47	7.7	395	14	1.40	7.9	430
20	76.0	1	4.90	22.6	350	12	1.00	7.9	600
21	76.0	1	4.90	22.6	350	15	1.10	7.6	525
22	76.0	1	4.90	22.6	350	17	1.50	8.1	410
23	76.0	11	4.48	24.3	410	17	1.50	8.1	410
24	68.4	16	4.25	24.3	390	17	1.35	8.1	410
25	66.6	18	2.57	13.3	345	17	1.32	8.1	410
26	71.8	16	4.33	24.5	405	15	1.10	7.4	480
27	76.0	17	1.31	8.1	470		....	....	...
28	76.0	17	1.31	8.1	470	17	1.40	7.6	415
29	76.0	18	3.01	13.3	335	19	1.38	8.6	475
30	76.0	1	3.83	22.5	445	19	1.38	8.6	475
31	76.0	1	3.83	22.5	445	20	1.20	8.3	525
32	76.0	20	1.22	8.1	505	20	1.20	8.3	525
33	76.0	20	1.22	8.1	505		....	....	...
34	76.0	21	7 pints	unknown	85	20	1.20	8.3	525
35	76.0	12	1.32	8.5	490		....	....	...
36	76.0	12	1.32	8.5	490	12	1.30	8.8	515
37	76.0	22	1.03	7.7	565	22	1.35	8.3	465
38	76.0	1	3.55	23.5	505	14	1.35	8.3	465
39	75.2	1	3.50	23.5	505		....	....	...
40	68.4	1	3.19	23.5	505	1	4.00	23.8	405
41[c]	33.3	23	0.81	9.4	385	1	1.95	23.8	405
42	72.3	1	3.36	23.5	505	2	2.80	11.3	290
43	76.0	1	3.55	23.5	505	3	2.86	18.4	490
44	76.0	4	2.16	14.5	510	3	2.86	18.4	490
45[b]	76.0	5	2.26	12.6	425	3	2.86	18.4	490
46[b]	76.0	6	7.52	38.6	390	3	2.86	18.4	490
47	76.0	7	4.59	22.3	370	3	2.86	18.4	490
48	76.0	3	3.36	16.2	365	3	2.86	18.4	490
49[b]	76.0	3	3.36	16.2	365		....	....	...
50	76.0	8	2.72	12.1	340	8	2.60	13.5	395
51	76.0	9	4.20	23.5	425		....	....	...
52	76.0	9	4.20	23.5	425	9	2.95	20.9	540
53	76.0	10	2.24	8.6	290	9	2.95	20.9	540
54	76.0	11	4.90	25.9	400	12	1.35	8.6	485
55[b]	73.5	6	6.00	35.6	435	12	1.30	8.6	485

[a] A detailed description of the paints is given in Table 1.
[b] The following paints were thinned to obtain better spraying consistency:
Panel 5 — Red lead (linseed oil) — 12 ounces of turpentine added to 9.08 pounds of red lead.
Panel 14 — Red lead (linseed oil) — 2 ounces of turpentine added to 7.70 pounds of red lead. Mixed more thoroughly than for Panel 5.
Panels 16 and 45 — Zinc chromate-iron oxide — 3 ounces of turpentine added to 5.77 pounds of paint.
Panels 46 and 55 — Red lead (linseed oil) — 6½ ounces of turpentine added to 18.5 pounds of paint. About 5 ounces of linseed oil added to paint for Panel 55.
Panel 49 — Red MZP — 1 ounce of turpentine added to 1 cup of paint.
[c] Only the north side of Panel 41 was painted. A new galvanized sheet was placed on the southern exposure before the paint tests started.

Table 2. — Concluded

Panel No.	Panel area (square feet)	First coat: Paint No.[a]	First coat: Amount of paint used (pounds)	First coat: Weight per gallon (pounds)	First coat: Coverage (square feet per gallon)	Second coat: Paint No.[a]	Second coat: Amount of paint used (pounds)	Second coat: Weight per gallon (pounds)	Second coat: Coverage (square feet per gallon)
56	66.6	13	4.90	25.7	350	12	1.18	8.6	485
57	67.6	23	1.40	8.6	415	12	1.20	8.6	485
58	74.1	4	2.55	14.4	420	12	1.32	8.6	485
59	76.0	14	1.20	8.0	505		....	....	...
60	76.0	14	1.20	8.0	505	14	1.45	8.6	450
61	76.0	1	3.32	23.5	535	12	1.25	8.3	500
62	76.0	1	3.32	23.5	535	15	1.50	8.3	420
63	76.0	1	3.32	23.5	535	17	1.29	8.2	485
64	76.0	11	4.25	26.7	480	17	1.29	8.2	485
65	76.0	16	4.45	25.2	430	17	1.29	8.2	485
66	76.0	18	2.65	13.4	385	17	1.29	8.2	485
67	76.0	16	4.25	25.7	460	15	1.30	9.3	540
68	76.0	17	1.12	8.7	590		....	....	...
69	76.0	17	1.12	8.7	590	17	1.45	9.1	480
70	76.0	18	3.55	13.7	295	19	1.30	8.3	485
71	73.6	1	3.70	24.1	480	19	1.26	8.3	485
72	66.6	1	3.34	24.1	480	20	.74	7.7	690
73	66.4	20	1.14	8.6	500	20	.74	7.7	690
74	72.8	20	1.26	8.6	500		....	....	...
75	74.0	21	7 pints	unknown	85	20	.83	7.7	690
76	74.0	12	1.30	8.5	485		....	....	...
77	74.0	12	1.30	8.5	485	12	1.55	8.1	385
78	76.2	22	1.00	8.2	625	22	1.35	8.1	455
79	76.2	1	3.70	24.6	505	14	1.50	8.1	410
80	76.2	1	3.70	24.6	505		....	....	...
81	82.6	1	4.00	24.6	505	1	4.10	24.8	500

These panels were painted without using the shield or cleaning the cup after painting each panel. Average values are given for successive panels when the same paint was used.

Inspections

Inspections were made each year (1950 through 1959, with the exception of 1955) by members of the Farm Structures Division of the Department of Agricultural Engineering. Since most of the inspectors worked with the project four years in succession, they developed proficiency in judging the panels. The yearly inspections were made by the inspectors viewing each panel from a platform at eave height. A high platform was built over a pickup truck so that it could be moved along the eaves as the inspections were made. Each panel was studied and the percent of film failure was recorded. The north and south exposures were inspected separately.

Criteria for Evaluating Tests

An important consideration in evaluating paint tests is to select an objective method for determining the life of a paint system. Browne (2) lists people in four categories according to their use of paint as

those who (a) paint for appearance; (b) paint when the film shows signs of failing but is not badly deteriorated; (c) paint long after the surface should have been painted; and (d) do not paint at all.

Obviously, each of these groups has a different idea of when the "repaint stage" is reached. To evaluate paint tests, the repaint stage must be defined. Singleton (9) states that "To the larger body of technical men who are paint users rather than paint makers, panel tests are only incidental. These men are concerned with the cost and the quality of protection that the paint will give on structures in service. The goal of panel testing should be not merely to compare different paint combinations, but to determine the life of the paint on the structure. The results should be a quantitative figure representing the life of the paint system in months or years to a stage where repainting is necessary."

One way to define repaint stage is to compare the condition of a panel with the ASTM photographic standards (12) as adopted in 1943 and reapproved without change in 1958. Numerous authorities (Singleton, Walton, Burgener) have recommended ASTM No. 8 as the stage in the photographic standards when repainting is necessary (Fig. 4). This standard corresponds to a film failure of about 5 percent (4). For comparison of paint performance in this test, 5-percent film failure was used as the repaint stage. All panels did not reach 5-percent film failure or repaint stage during the 10-year test period.

Photographic reference standard Number 8 — type 1, rusting not accompanied by blistering. This standard has often been recommended as the "repaint stage." Photo courtesy American Society for Testing Materials. (See literature citation 12.) (Fig. 4)

TEST RESULTS

Performance of Paint Systems

The paint-performance data for all paint systems are summarized in Table 3. The average percent film-failure ratings are listed for the 9 inspections (1949 to 1959, with the exception of 1955). The percent film-failure rating is an estimate of the percent of total area of the panel where the paint film failed and rust occurred. The southern and northern exposures of each panel were graded separately. Since the panels had one replication, the film-failure values listed in the table are an average for two panels. For the sake of convenience, any film failure below 1 percent was coded as 0.5 percent.

The relative durability of each paint system is shown by the "time to repaint stage." This stage represents the approximate time at which 5 percent of the surface of the test panel was devoid of paint. In the two-coat systems, the degree of failure applied to both coats of paint. A number of paint systems did not have a film failure of 5 percent at the end of 10 years and, therefore, did not reach repaint stage.

Table 4 lists the 15 paint systems with the smallest percent of film failure after 10 years' exposure. Since most of the panels did not reach repaint stage in 10 years, the paints were ranked according to the average percent film failure at that time. The last four paint systems reached the repaint stage before the end of 10 years.

The aluminum paints used as a second coat over red lead or gray MZP (Metallic Zinc Paint) gave the best overall performance. All of the panels painted a first coat of red lead and a second coat of one of the aluminum paints (other than asphalt aluminum) performed well. A large number of the panels painted with a base coat of gray MZP and a second coat of one of the aluminum paints did not reach repaint stage after 10 years' exposure. The panels with two coats of gray MZP were nearing repaint stage at the end of 10 years.

Table 5 summarizes the results of all one-coat paint systems and all paint systems composed of two coats of the same paint. In the one-coat paint systems, the performance of red MZP and gray MZP was about the same. Each gave approximately 5 years' protection before repaint stage. All single-coat paint systems of MZP gave a better performance than single coats of aluminum paint.

When two applications of the same paint were used, gray MZP (soybean oil, paint No. 1) gave the best performance — over 10 years' protection. The paint system composed of two coats of aluminum (paint No. 12, aluminum for metal and masonry) protected the panel for over 8 years before repaint stage was reached.

Table 3. — Performance of Paint Systems, 1949-1959 (Excluding 1955)

Paint system[a]	Exposure	Original surface condition (percent rusty)[b]	Paint No. (first coat)[c]	Paint No. (second coat)[c]	Average film failure, percent[d] 1950	1951	1952	1953	1954	1956	1957	1958	1959	Time to repaint stage (years)[e]
1	S	80.0	1	2	0	.25	.50	1.00	6.00	11.50	14.00	17.00	17.00	5
	N	65.0			0	.75	.75	.75	10.00	10.00	10.00	10.00	11.50	4½
2	S	67.5	1	3	0	0	0	0	.25	10.25	13.00	13.50	13.50	6
	N	60.0			0	0	0	0	0	0	0	0	0	over 10
3	S	72.5	4	3	0	0	0	0	.75	16.50	19.00	22.50	23.50	5½
	N	65.0			0	0	0	0	0	.25	.25	.25	.25	over 10
4	S	80.0	5	3	0	.25	.75	1.25	14.00	50.00	52.50	55.00	55.00	4½
	N	70.0			0	0	0	0	.25	3.00	4.50	5.50	7.50	8½
5	S	82.5	6	3	0	.50	1.25	2.50	25.00	40.00	45.00	52.50	53.50	4
	N	85.0			0	0	0	0	.50	5.00	6.00	7.50	9.00	7
6	S	82.5	7	3	0	0	0	.25	3.00	22.50	22.50	25.00	25.00	5
	N	80.0			0	0	0	0	0	1.25	2.00	2.50	3.00	over 10
7	S	45.0	3	3	0	0	0	0	0	10.50	10.50	14.00	14.00	6
	N	80.0			0	0	0	0	0	.25	.25	.50	1.00	over 10
8	S	68.5	3	none	.25	1.00	1.50	2.50	30.25	37.50	38.00	38.50	38.50	4
	N	85.0			0	.75	1.25	2.25	4.25	4.25	8.50	10.50	13.00	7
9	S	66.5	8	8	.25	1.75	1.75	3.50	22.50	37.50	37.50	41.00	47.50	4
	N	90.0			0	.75	1.75	2.75	19.00	33.50	36.50	42.00	46.00	4
10	S	77.5	9	none	2.00	12.50	15.25	20.50	37.00	45.00	47.50	48.50	48.50	1½
	N	85.0			.25	.75	1.75	2.75	16.00	22.00	22.00	22.00	25.00	4
11a[f]	S	80.0	9	10	0	0	0	3.00	25.00	45.00	45.00	50.00	55.00	4
	N	70.0			0	0	0	0	0	0	.50	1.00	1.00	over 10
11b[f]	S	70.0	9	9	0	0	0	1.00	5.00	15.00	15.00	16.00	17.00	5
	N	100.0			0	0	0	0	0	3.00	3.00	4.00	5.00	10
12	S	75.0	10	9	.25	.50	1.25	2.00	12.50	22.50	22.50	22.50	22.50	4½
	N	75.0			0	.25	.25	.50	2.00	4.00	6.25	7.75	8.75	7½
13	S	70.0	11	12	0	0	0	0	0	1.00	1.00	1.75	2.50	over 10
	N	75.0			0	0	.25	.25	.50	2.00	2.00	2.00	2.25	over 10
14	S	65.0	6	12	0	0	0	.25	.25	3.00	3.00	3.25	3.50	over 10
	N	82.5			0	.25	.50	1.00	3.50	10.25	13.00	13.50	17.00	5½
15	S	70.0	13	12	0	0	0	0	0	1.25	1.75	2.25	2.50	over 10
	N	82.5			0	.25	.25	.25	1.00	5.25	6.50	8.00	10.00	7

(For footnotes, see page 18.)

Table 3. — Continued

Paint system[a]	Exposure	Original surface condition (percent rusty)[b]	Paint No. (first coat)[c]	Paint No. (second coat)[c]	Average film failure, percent[d]									Time to repaint stage (years)[e]
					1950	1951	1952	1953	1954	1956	1957	1958	1959	
16a[g]	S	85.0	5	12	0	.50	.50	.50	.50	.50	5.00	6.00	6.00	8
	N	60.0			0	0	0	0	1.00	3.00	3.00	3.00	3.00	over 10
16b[g]	S	55.0	23	12	0	.50	.50	1.00	1.00	2.00	2.00	3.00	4.00	over 10
	N	100.0			0	5.00	5.00	10.00	50.00	60.00	60.00	65.00	65.00	2
17	S	80.0	4	12	0	.25	.25	.25	.50	2.00	2.50	3.00	3.50	over 10
	N	79.0			0	.50	.50	2.00	5.00	7.50	8.50	8.50	10.50	5
18	S	75.0	14	none	.50	22.50	27.50	35.00	65.00	77.50	77.50	85.00	90.00	1
	N	80.0			10.25	36.50	46.50	52.50	62.50	67.50	67.50	67.50	70.00	½
19	S	80.0	14	14	0	1.00	2.00	3.00	6.00	16.50	16.50	17.50	21.00	4½
	N	82.5			0	1.50	1.50	2.50	15.25	17.75	17.75	17.75	19.00	4
20	S	82.5	1	12	0	0	0	.25	.25	2.25	2.25	2.50	3.50	over 10
	N	80.0			0	0	0	.25	.25	1.25	2.25	2.25	2.75	over 10
21	S	80.0	1	15	0	0	0	0	.50	4.25	4.25	4.25	4.50	over 10
	N	82.5			0	0	.25	.25	.50	2.50	3.00	3.00	3.00	over 10
22	S	75.0	1	17	0	.25	.25	.25	1.00	7.75	7.75	8.00	9.50	6
	N	85.0			0	0	.25	.25	.25	4.50	5.00	6.00	7.50	8
23	S	80.0	11	17	0	0	0	.25	1.75	8.50	8.50	10.00	13.00	6
	N	80.0			0	0	0	.50	2.50	4.50	6.00	7.25	8.50	7½
24	S	82.5	16	17	0	.75	.75	.75	2.00	12.50	12.50	14.50	17.50	5½
	N	80.0			0	0	0	.25	.50	4.25	5.25	6.25	7.75	8
25	S	60.0	18	17	0	0	0	0	0	.25	.25	.25	.50	over 10
	N	80.0			0	0	0	0	0	.75	1.75	1.75	2.75	over 10
26	S	57.5	16	15	0	0	0	.25	.50	2.25	2.25	2.50	2.50	over 10
	N	90.0			0	0	.50	.50	.75	4.50	5.50	6.50	7.00	7½
27	S	60.0	17	none	3.00	17.50	19.00	21.00	65.00	75.00	75.00	80.00	87.50	1
	N	95.0			22.75	55.00	57.50	60.00	75.00	77.50	77.50	77.50	80.00	(less than ½)
28	S	57.5	17	17	0	.50	1.25	1.25	1.75	4.50	4.50	5.00	5.00	10
	N	80.0			0	.50	1.00	1.50	7.50	10.00	10.25	11.50	11.50	4½
29	S	62.5	18	19	0	0	0	0	0	0	0	.25	.25	over 10
	N	85.0			0	0	.25	.25	.50	1.50	2.00	2.50	2.50	over 10
30	S	67.0	1	19	0	0	.25	.25	.75	3.00	4.00	4.50	5.00	10
	N	82.5			0	0	0	0	0	.25	.50	.50	.50	over 10

(For footnotes, see page 18.)

Table 3. — Concluded

Paint system[a]	Exposure	Original surface condition (percent rusty)[b]	Paint No. (first coat)[c]	Paint No. (second coat)[c]	Average film failure, percent[d] 1950	1951	1952	1953	1954	1956	1957	1958	1959	Time to repaint stage (years)[e]
31	S	74.0	1	20	0	0	.50	1.00	5.00	7.75	8.00	10.50	12.50	5
	N	85.0			0	0	.25	.50	4.00	5.25	6.25	6.25	9.00	6½
32	S	51.0	20	20	0	1.50	1.50	2.75	5.50	18.00	18.50	22.00	24.50	5
	N	85.0			0	1.50	2.75	3.25	25.50	37.50	38.00	41.00	44.00	4
33	S	62.5	20	none	10.00	23.00	26.00	27.50	75.00	80.00	80.00	85.00	87.50	½
	N	85.0			7.50	15.00	20.00	42.50	75.00	85.00	87.50	90.00	92.50	½
34	S	66.0	21	20	0	0	0	0	.25	22.00	22.00	27.50	33.50	5½
	N	80.0			0	0	0	0	.25	.75	1.25	3.00	5.50	10
35	S	79.0	12	none	9.00	10.00	11.50	15.00	42.50	47.50	47.50	47.50	47.50	½
	N	80.0			22.50	40.00	40.00	45.25	47.50	52.50	53.50	53.50	53.50	(less than ½)
36	S	76.0	12	12	0	.25	.50	.50	2.00	3.00	3.00	3.00	3.00	over 10
	N	80.0			0	.25	.50	1.50	4.00	5.00	5.00	6.00	6.50	7
37	S	81.0	22	22	1.00	3.00	5.00	6.50	25.00	47.50	47.50	52.50	57.50	3
	N	80.0			.25	15.25	15.25	30.25	40.50	46.50	47.00	50.50	52.00	1½
38	S	71.0	1	14	0	0	0	.25	.25	.50	.75	1.25	1.75	over 10
	N	80.0			0	0	0	.25	.25	.50	1.50	2.25	3.00	over 10
39	S	65.0	1	none	0	0	0	.75	3.50	12.50	12.50	13.50	15.00	5½
	N	80.0			0	.25	.25	.50	8.00	20.00	20.00	23.50	29.00	4½
40	S	65.0	1	1	0	0	0	.50	1.50	4.00	4.00	4.00	5.00	10
	N	80.0			0	0	0	0	.50	2.25	4.25	4.25	4.25	over 10
41a[h]	S	00.0	new sheet		0	0	0	0	0	15.00	17.00	20.00	20.00	5½
41b[h]	N	60.0	23	1	0	0	0	0	0	.50	.50	.50	3.00	over 10

[a] The paint-system numbers correspond to the first 40 panels. Panels 42 through 81 were replicates of the first 40 panels.

[b] These values are the percent of the total panel area that was rusty as estimated from colored slides of the panels before painting. Each reading is an average of two panels.

[c] A detailed description of the paints is given in Table 1.

[d] Except for Panels 11, 16, and 41, all values are the average of two panels. The percent film failure is the percent of total area of the panel where the paint failed and rust occurred.

[e] Values were calculated to the nearest one-half year.

[f] Panel 11 (Paint System 11a) was painted a first coat of green MZP and a top coat of green auto enamel as planned, but Panel 52 (Paint System 11b) was painted two coats of green MZP. The film-failure values for these two systems are for only one panel each.

[g] All of the zinc chromate-iron oxide paint (Paint No. 5) was used on Panel 16 (Paint System 16a). Special red primer was used on Panel 57 (Paint System 16b). The film-failure values for these two systems are for only one panel each.

[h] The southern exposure of Panel 41 (Paint System 41a) was replaced with a new galvanized sheet and left unpainted. The northern exposure (Paint System 41b) was painted with a special red primer and a second coat of gray MZP.

Table 4. — Performance of Paint Systems With Smallest Percent of Film Failure

Rank	Paint system	Paint No.[a] (first coat)	Paint No.[a] (second coat)	Film failure at 10 years, percent		
				Southern exposure[b]	Northern exposure[b]	Average
1	29	18	19	.25	2.50	1.38
2	25	18	17	.50	2.75	1.62
3	38	1	14	1.75	3.00	2.38
4	13	11	12	2.50	2.25	2.38
5	30	1	19	5.00	.50	2.75
6	20	1	12	3.50	2.75	3.12
7	21	1	15	4.50	3.00	3.75
8	16a	5	12	6.00[c]	3.00[c]	4.50
9	40	1	1	5.00	4.25	4.62
10	26	16	15	2.50	7.00	4.75
11	36	12	12	3.00	6.50	4.75
12	15	13	12	2.50	10.00	6.25[d]
13	2	1	3	13.50	0	6.75[d]
14	17	4	12	3.50	10.50	7.00[d]
15	7	3	3	14.00	1.00	7.50[d]

[a] A detailed description of the paints is given in Table 1.
[b] Except for Paint System 16a, all values are the average of two panels.
[c] Film-failure value is for only one panel. See footnote g, Table 3.
[d] Reached repaint stage before the end of 10 years.

Table 5. — Performance of One-Coat Paint Systems and Paint Systems With Two Coats of the Same Paint

Rank	Paint system	Paint No.[a]	Film failure at 10 years, percent			Time to repaint stage (years)[c]
			Southern exposure[b]	Northern exposure[b]	Average	
			One-coat paint systems			
1	8	3	38.5	13.00	28.50	5½
2	39	1	15.0	29.00	22.00	5
3	10	9	48.5	25.00	36.80	3
4	18	14	90.0	70.00	80.00	1
5	35	12	47.5	53.50	50.50	½
6	27	17	87.5	80.00	83.80	½
7	33	20	87.5	92.50	90.00	½
			Two-coat paint systems			
1	40	1	5.0	4.25	4.62	over 10
2	36	12	3.0	6.50	4.75	over 8½
3	7	3	14.0	1.00	7.50	over 8
4	28	17	5.0	11.00	8.00	7½
5	11b	9	17.0[d]	5.00[d]	11.00	7½
6	32	20	24.5	44.00	34.25	4½
7	19	14	21.0	19.00	20.00	4
8	9	8	47.5	46.00	46.50	4
9	37	22	57.5	52.00	54.75	2

[a] A detailed description of the paints is given in Table 1.
[b] Except for Paint System 11b, all values are the average of two panels.
[c] Values were calculated to the nearest one-half year.
[d] Film-failure value is for only one panel. See footnote f, Table 3.

Table 6 summarizes the results of all paint systems that had a base coat of gray MZP. In general, the paint systems that had an aluminum paint top coat over a gray MZP base coat again gave the best performances.

Table 6. — Performance of Paint Systems With Gray MZP Base Coat

Rank	Paint system	Paint No.[a] (first coat)	Paint No.[a] (second coat)	Film failure at 10 years, percent			Time to repaint stage (years)[c]
				Southern exposure[b]	Northern exposure[b]	Average	
1.........	38	1	14	1.75	3.00	2.37	over 10
2.........	13	11	12	2.50	2.25	2.37	over 10
3.........	20	1	12	3.50	2.75	3.12	over 10
4.........	21	1	15	4.50	3.00	3.75	over 10
5.........	30	1	19	5.00	.50	2.75	over 10
6.........	40	1	1	5.00	4.25	4.62	over 10
7.........	26	16	15	2.50	7.00	4.70	over 9
8.........	2	1	3	13.50	0	6.75	over 8
9.........	22	1	17	9.50	7.50	8.50	7
10.........	24	16	17	17.50	7.75	12.62	6½
11.........	23	11	17	13.00	8.50	10.75	6½
12.........	31	1	20	12.50	9.00	10.75	6
13.........	1	1	2	17.00	11.00	14.00	4½

[a] A detailed description of the paints is given in Table 1.
[b] All values are the average of two panels.
[c] Values were calculated to the nearest one-half year.

Figs. 5 through 8 show the performance over the 10-year period of the metallic zinc paints, the aluminum paints, all paint systems with a gray MZP base coat, and all paint systems with red lead, white lead, or zinc chromate for the base coat, respectively. All values on these graphs are averages for north and south exposures.

Effect of Exposure

Exposure had an appreciable effect on the performance of the red and green paints, but no apparent effect on the paint systems with an aluminum paint top coat. Table 7 summarizes the 10-year performance of all paint systems with a red or green top coat and all paints with an aluminum paint top coat.

In every case, the film failures from the paint systems with a red or green top coat were larger for the southern exposure than for the northern exposure. The exposure did not seem to affect the performance of the paint systems that had a second coat of one of the aluminum paints. Fig. 9 shows the contrast between the two groups of paints. The average film failures at 10 years were almost equal (20.3 compared with 22.0) for the northern and southern exposures of the paint systems

Table 7. — Effect of Southern and Northern Exposures on Paint Performance

Paint system	Paint No.[a] (first coat)	Paint No.[a] (second coat)	Film failure at 10 years, percent	
			Southern exposure[b]	Northern exposure[b]
Paint systems with red and green top coats				
2	1	3	13.50	0
3	4	3	23.50	.25
4	5	3	55.00	7.50
5	6	3	53.50	9.00
6	7	3	25.00	3.00
7	3	3	14.00	1.00
8	3	none	38.50	13.00
10	9	none	48.50	25.00
11a	9	10	55.00[c]	1.00[c]
11b	9	9	17.00[c]	5.00[c]
12	10	9	22.50	8.75
Average			34.50	9.90
Paint systems with aluminum top coats				
13	11	12	2.50	2.25
14	6	12	3.50	17.00
15	13	12	2.50	10.00
16a	5	12	6.00[c]	3.00[c]
16b	23	12	4.00[c]	65.00[c]
17	4	12	3.00	10.50
18	14	none	90.00	70.50
19	14	14	21.00	19.50
20	1	12	3.50	2.75
21	1	15	4.50	3.00
22	1	17	9.50	7.50
23	11	17	13.00	8.50
24	16	17	17.50	7.75
25	18	17	.25	.50
26	16	15	2.50	7.00
27	17	none	87.50	80.00
28	17	17	5.00	11.50
29	18	19	.25	2.50
30	1	19	5.00	.50
31	1	20	12.50	9.00
32	20	20	24.50	44.00
33	20	none	87.50	92.50
34	21	20	33.50	5.50
35	12	none	47.50	53.50
36	12	12	3.00	6.50
37	22	22	57.50	52.50
38	1	14	1.75	3.00
Average			20.30	22.00

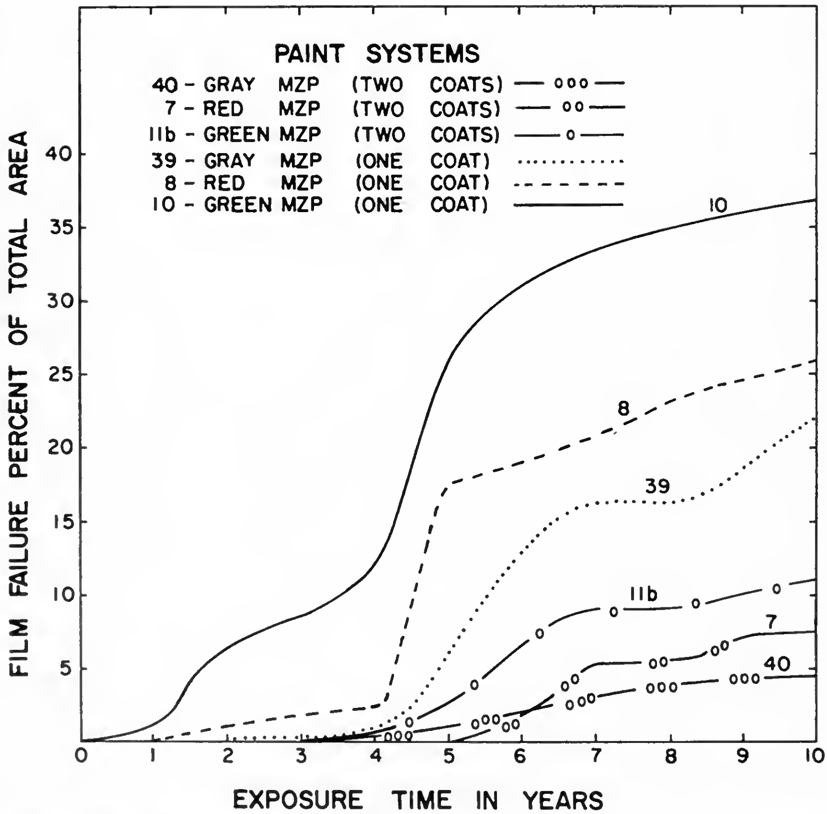
[a] A detailed description of the paints is given in Table 1.
[b] Except for Paint Systems 11a, 11b, 16a, and 16b, all values are the average of two panels.
[c] Film-failure values are for only one panel. See footnotes f and g, Table 3.

that had an aluminum second coat. There was a large difference, however (34.5 compared with 9.9), between paint systems with a second coat of red or green paint. The kind of exposure did not seem to affect the performance of the gray MZP.

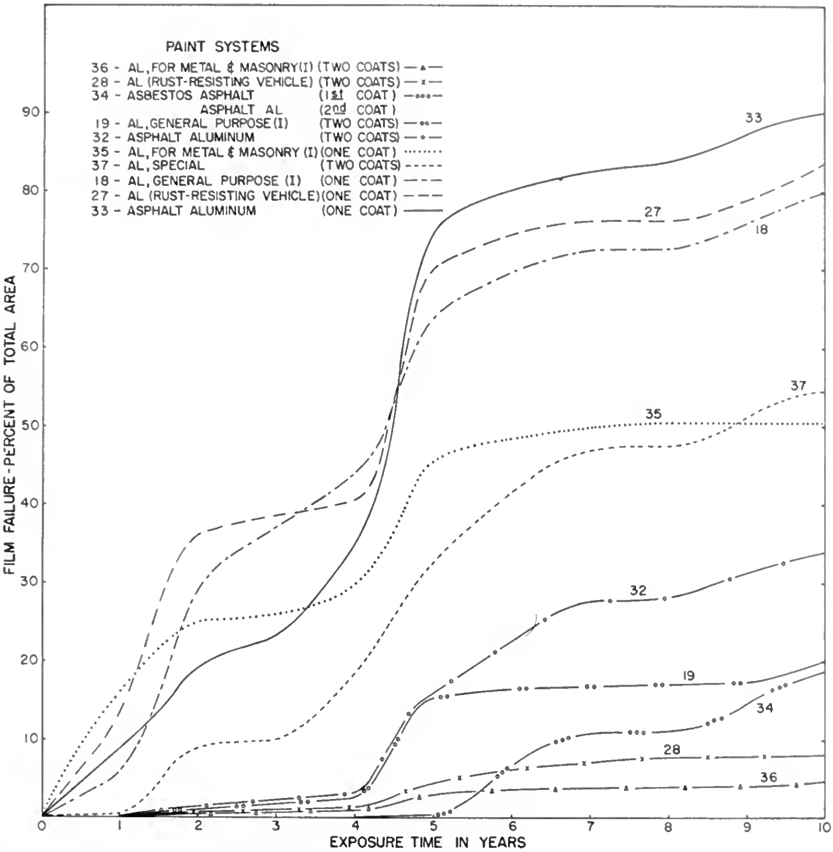
Effect of Original Condition of Sheet

The original condition of the metal sheets on the test crib varied from 45 to 100 percent rusty (see Table 3).

The panels on the northern exposure for the second replication were 100 percent rusty when they were painted, and the average film failure at the end of 10 years was 28.4 percent. The panels for the first replication on the northern exposure varied from 50 to 90 percent rusty, with an average of 65 percent rusty, and the average film failure



Performance of metallic zinc paints. (Fig. 5)



Performance of aluminum paints. **(Fig. 6)**

at the end of 10 years was only 7.8 percent. The difference between these two averages indicates that the original condition of the panels had a definite effect on the performance of the paint systems.

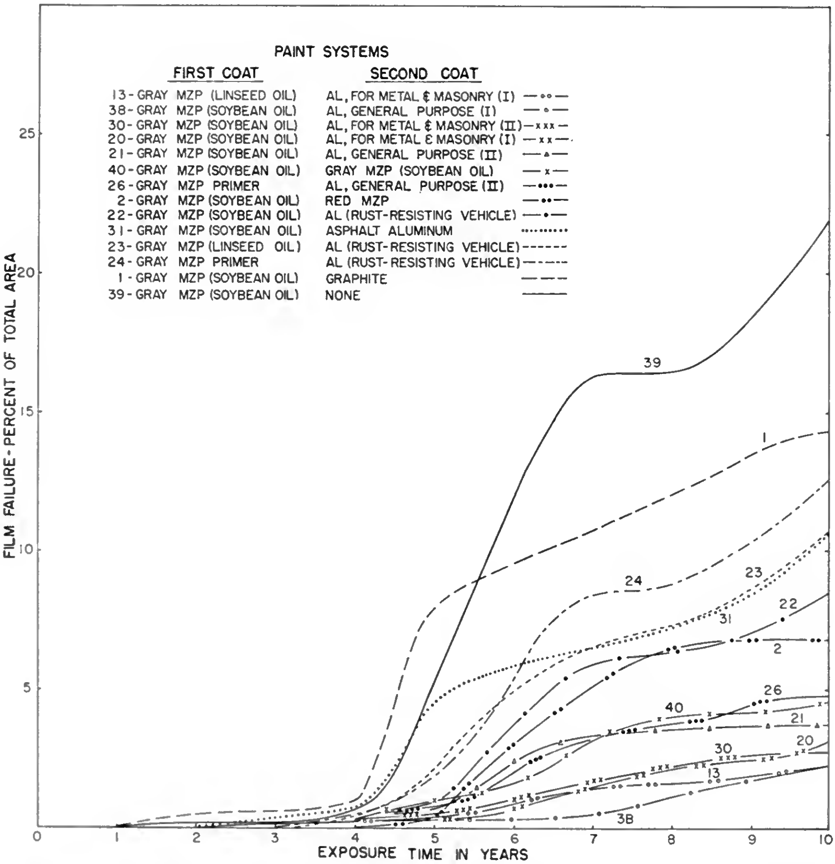
Effect of Wire Brushing Sheets Before Applying Paint

One of the objectives of this test was to evaluate the practice of brushing a rusty galvanized sheet before applying paint. In preparation for painting, all of the panels were swept with a broom to remove all foreign material.

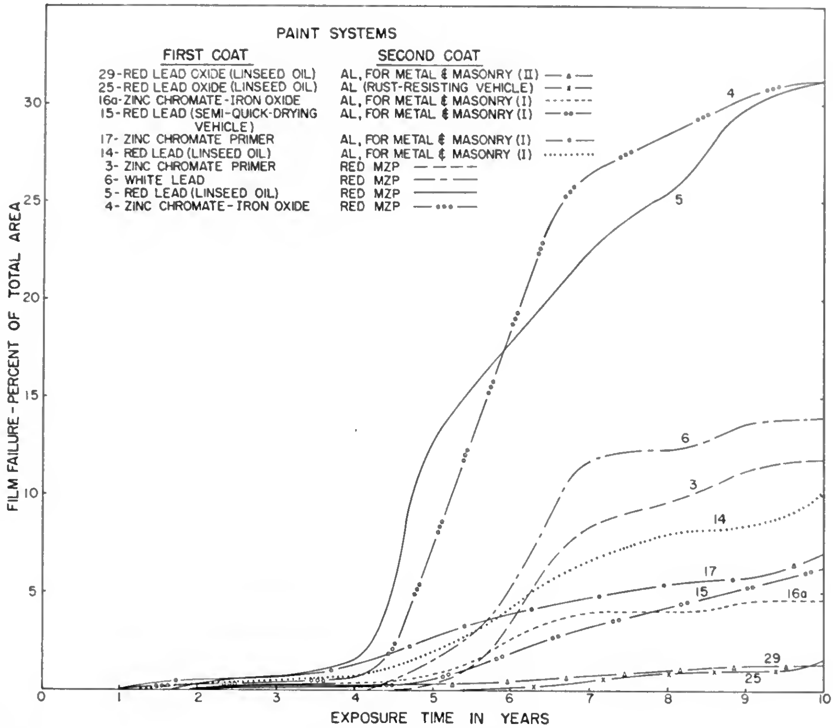
The top portions of the bottom sheets of panels 46 through 81 on the northern exposure were wire brushed before painting (Fig. 10). These sheets were inspected each year. During the tenth yearly in-

spection, panels 46 through 81 were studied with special care to see if any difference existed between the paint performance of the sections that had been wire brushed and the remaining portions of the panels. As far as could be determined, the wire brushing had no effect on the ability of the paint to withstand weathering.

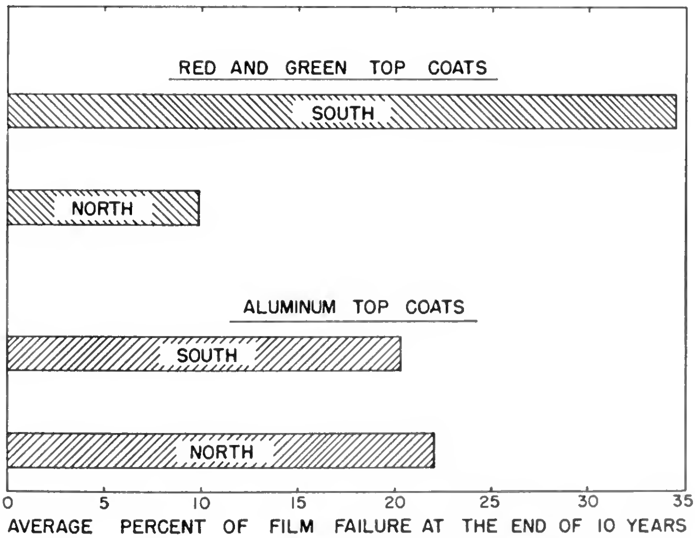
This conclusion agrees with the finding of Walton (13). After a 7-year paint study at Pennsylvania State University, Walton stated that "In preparing a rusty steel roof for painting, it is unnecessary to wire brush the surface to free it of rusty particles. It will be sufficient to whisk the surface free of loose particles of foreign matter." Matthews (8) also observed that steel brushing was unnecessary in the preparation of rusty galvanized sheets for painting.



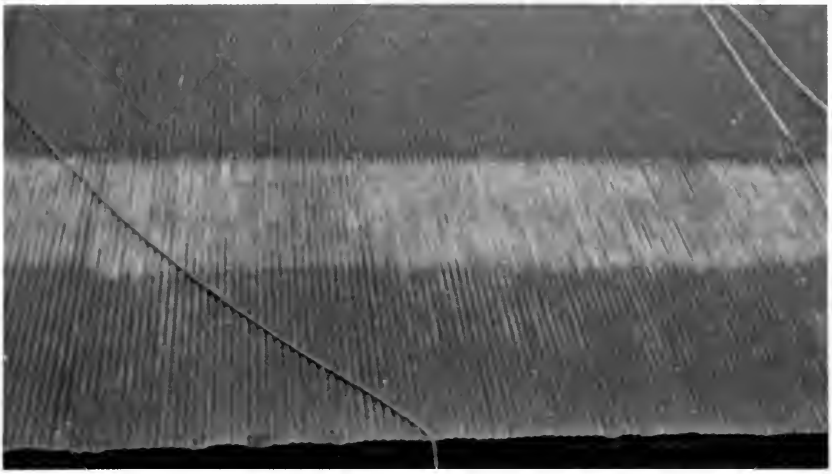
Performance of paint systems with gray MZP for a first coat. **(Fig. 7)**



Performance of paint systems with red lead, white lead, or zinc chromate for a first coat. (Fig. 8)



Effect of exposure on red and green top coats and aluminum top coats (Fig. 9)



The top portions of the bottom sheets of Panels 46 through 81 on the north side were wire brushed before painting. These panels were 100 percent rusty (see Fig. 2). (Fig. 10)

SUMMARY

Among the general conclusions drawn from this study, the following are most significant.

1. Exposure had a definite effect on the paint systems with a red or green top coat, but no apparent effect on the paint systems with an aluminum top coat. All panels with a paint system composed of a red or green top coat had an appreciably larger film failure on the southern exposure than on the northern exposure. There was no significant difference between film failures on the northern and southern exposures for the aluminum top coats, or for the gray MZP top coat.

2. The original condition of the panel affected the amount of protection offered by the paint system. The greater the amount of rust when the panel was painted, the faster the paint film failed.

3. The paint systems that provided the best protection were those with a first coat of red lead and a second coat of an aluminum paint and those with a first coat of gray metallic zinc paint and a second coat of an aluminum paint.

4. Wire brushing before painting gave no apparent increased protection to the panels. If the panels had not been brushed, however, more paint would have been necessary to secure a good coverage.

LITERATURE CITATIONS

1. Bartells, G. C. Test results of metallic zinc paint on galvanized sheet metal. Agr. Engin. 20:101-103. 1939.
2. Browne, F. L. Testing house paints for durability. U. S. Dept. Agr. Forest Prod. Lab., Madison, Wis.
3. Burgener, M. L., and Carter, D. G. Protective coatings for weathered galvanized sheets. Agr. Engin. 31:67-70. 1950.
4. Burgener, M. L., and Carter, D. G. Durability of paints on weathered galvanized roofing. Ill. Agr. Exp. Sta. Bul. 565. 16p. 1953.
5. Evans, U. R. Metallic corrosion passivity and protection. Edward Arnold and Co. London. 720p. 1938.
6. Hocker, C. D. Outdoor test results on bare and metal-coated ferrous specimens. Symposium on the outdoor weathering of metals and metallic coatings, pp. 1-19. Regional meeting ASTM, Washington, D. C. 1934.
7. Irish, W. W. Illinois farm building activities and trends, 1944-1954. Unpublished Master's thesis. Univ. of Ill. 1955.
8. Matthews, C. A. Spray painting farm metal roofs. Agr. Engin. 29:542-544. 1948.
9. Singleton, W. F. The interpretation of visual rusting standards. Proc. ASTM 44:910-915. 1944.
10. Speller, F. N. Corrosion, causes and prevention. McGraw-Hill. New York. 686p. 3d ed. 1951.
11. Standard method of conducting exterior exposure tests of paint on steel (D1014-51). ASTM Standards 8:846-874. 1958.
12. Standard method of evaluating degree of resistance to rusting obtained with paint on iron and steel surfaces (D610-43). ASTM Standards 8:875-880. 1958.
13. Walton, H. V. Painting galvanized steel roofing: exposure studies. Pa. Agr. Exp. Sta. Prog. Rpt. 139. 11p. 1955.

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